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DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

Technical Report 1709-TR

# ENGINEERING REPORT OF 6,000-BTU/HR AIR CONDITIONING UNIT

Task 8F71-11-001-03

15 March 1962

U S Army
Engineer Research And
Development Laboratories

FORT BELVOIR, VIRGINIA

AD ______ Accession No. ______
U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia - ENGINEERING REPORT OF 6,000-BTU/HR AIR CONDITIONING UNIT - John L. McDonald and L. E. Adkins

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2. Contracts DA-44-009 ENG-4005
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# 6,000-BTU/HR AIR CONDITIONING UNIT

Task 8F71-11-001-03

15 March 1962

Distributed by

The Director
U. S. Army Engineer Research and Development Laboratories
Corps of Engineers

Prepared by

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Corps of Engineers
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Fort Belvoir, Virginia

# PREFACE

Authority for conducting the development and tests covered by this report is contained in Task 8F71-11-001-03, "Air Conditioning, Van Type." A copy of the task card is contained in the appendix.

Engineering tests were conducted from May 1960 to March 1961 by John L. McDonald, Project Engineer, under the supervision of J. R. Mehalick, Chief, Heating and Air Conditioning Section, Special Equipment Branch, Civil Department.

CONTENTS

## SUMMARY

This report covers development and testing of a multipackage, self-contained, air-cooled, 6,000-Btu/hr, air conditioning unit to be used in all types of mobile trailers and expansible vans.

Project 8-71-11-400 was initiated in 1959 for the development and testing of two separate air conditioning units, one 60-cycle, single-phase, 115-volt, 6,000-Btu/hr unit and one 400-cycle, three-phase, 208-volt, 6,000-Btu/hr unit. Unsatisfactory results in both units necessitated further development which has been completed for the type 400 unit and is being continued for the type 60 unit.

Testing of the units was conducted at the U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia; Electrical Testing Laboratories, New York, New York; and Therm-Air Manufacturing Company, Peekskill, New York.

The report concludes:

a. The 6,000-Btu/hr, standard-weight, multipackage, 60-cycle, air conditioning unit (type 60) in the present stage of development meets the requirements of the military characteristics and the purchase description except for low cooling capacity and suspected low condenser fan motor horsepower.

b. The 6,000-Btu/hr, standard-weight, multipackage, 400-cycle, air conditioning unit (type 400 second-stage design) is satisfactory and meets the requirements of the military characteristics as outlined in the project card and the purchase description except for minor deficiencies.

c. The tested air conditioner design can only be reproduced by using manufacturing drawings as a purchase requirement.

d. Since the 400-cycle version has had the equivalent of a Service Test, it is now ready for type classification.

e. A louver arrangement to deflect the condenser discharge air upward as done in the Pershing huts would guard against possible recirculation and reduction of performance.

# ENGINEERING REPORT OF

# 6,000-BTU/HR AIR CONDITIONING UNIT

## I. INTRODUCTION

1. Subject. This report covers development and testing of a self-contained, air-cooled, multipackage, 6,000-Btu/hr, air conditioning unit for use in military-type vans and shelters.

2. Background. The development of this unit was initiated as a part of the overall development of a family of standard military air conditioners. Contract DA-44-009 Eng-4005 was awarded to Redmanson Corporation, York, Pennsylvania, on 29 May 1959 for development of three 60-cycle and three 400-cycle power versions of the unit.

During development of these units, the U. S. Army Ordnance Missile Command (AOMC) had a requirement for fifteen 400-cycle units for the Communications and Fire Control Shelters of the Pershing Missile System. The contract was modified in order to procure these units concurrently with the development units recognizing that design risks were involved.

Prototype test results revealed a requirement for improvement of design of the 6,000-Btu/hr unit. U. S. Army Ordnance Missile Command had a requirement for 18 additional 400-cycle units. A second development contract, DA-44-009 Eng-4566, was awarded to Therm-Air Manufacturing Company, Peekskill, New York, on 14 June 1960 for construction of two improved prototypes for development tests and for production of 18 units for AOMC's Pershing Missile requirements.

For purposes of this report, the unit as originally designed will be referred to as the "first-stage design." The modified type 400 unit will be referred to as the "second-stage design."

3. Military Characteristics. The military characteristics of the project are general for all air conditioners developed under the project. As stated in the MC's, the unit shall:

a. Operate on power from standard army generators readily available in the field.

b. Maintain temperature, humidity, and fresh air circulation necessary for proper functioning of the primary van-housed equipment and for comfort of operating personnel. Provisions for dust filtering and for protection against harmful chemical agents

shall be made for use with those installations requiring such protection.

c. Be capable of being mounted on or in the associated van by organizational maintenance personnel without requiring extensive modifications of the van or interfering with the efficient operation of the primary equipment.

d. Be sufficiently rugged to withstand prolonged cross-country hauling in a mounted position and be capable of operation continuously for 3,000 hours between major overhauls.

e. Have safety devices incorporated in the design to reduce fire hazards to a minimum. Operating personnel shall be protected from injuries by the mechanical and electrical parts of the equipment.

f. Operate at a noise level such that it will not interfere with the efficient operation of the equipment in the van. Appropriate components will be treated for the elimination of interference with radio communications in accordance with applicable Signal Corps specifications.

g. Be capable of satisfactory performance at any air temperature from $+60^{\circ}$ F to $+125^{\circ}$ F and while exposed to maximum solar radiation, and be capable of safe storage at temperatures from $-65^{\circ}$ F (for periods of several days at a time) to $+155^{\circ}$ F (for periods of at least 4 hours daily).

4. Purchase Description. Specific development requirements for the 6,000-Btu/hr unit not covered by the MC's but contained in the development purchase description (as modified) are as follows:

a. The unit shall have a maximum moisture content of 25 ppm by weight in the liquid phase after being dehydrated and charged with refrigerant.

b. The total weight of the unit charged and ready to operate shall not exceed 105 pounds for type 400 units and 115 pounds for type 60 units without accessories.

c. The unit shall have a total net cooling capacity of not less than 6,000 Btu/hr under the conditions shown in Table 1.

d. The evaporator section shall have an air flow of not less than 200 standard cfm.

e. The maximum total power requirements of the unit at the conditions specified in Table I shall not exceed 1,720 watts for type 400 and 1,200 watts for type 60.

Table I. Temperature Condition Requirements

| | Ambient Temperature (° F) | Room (or inside) | Temperature (° F) |
|---|---|---|---|
| Elevation | Dry Bulb | Dry Bulb | Wet Bulb |
| Sea Level | 125 | 90 | 75 |
| Sea Level | 95 | 80 | 67 |

f. The condensing pressure shall not exceed 263 psig and the suction pressure shall not drop below 40 psig when the evaporator and condenser sections are joined by 4 feet of refrigerant lines and when operating under conditions listed in Table I.

g. The unit shall have a ratio of 70 to 90 percent of room sensible cooling to net cooling effect.

h. The unit shall be able to withstand a charge of 300 psig plus or minus 5 psig of dry nitrogen containing 1/2 pound of refrigerant.

i. The unit shall have a minimum performance factor (expressed in cooling units per watt) based on the net total room cooling effect and total watts input in the unit of 4.45 Btu/watt/hr when operating under conditions specified in Table I.

## II. INVESTIGATION

5. First-Stage Design. The 6,000-Btu/hr, multipackage, self-contained, air-cooled unit consists of an evaporator section and a condenser section. Figures 1 through 6 show components of the unit.

The evaporator section consists of aluminum frame and panels, expansion valve, cooling coil, air filter, adjustable discharge grille, return and fresh air dampers, fan, and controls. The condenser section consists of aluminum frame and panels, compressor sealed with motor, fan, condensing coil, receiver, sight glass, and refrigerant drier-strainer. Accessories consist of interconnecting refrigerant and electrical lines and an optional time-delay box. The time-delay-relay box provides for sequence starting of two units. This is desirable while operating the two units on a fully loaded power source since the air conditioner is not designed for capacity modulation.

The two sections may be bolted together for use in unitary form or separated by distances up to 12 feet. Refrigerant connections

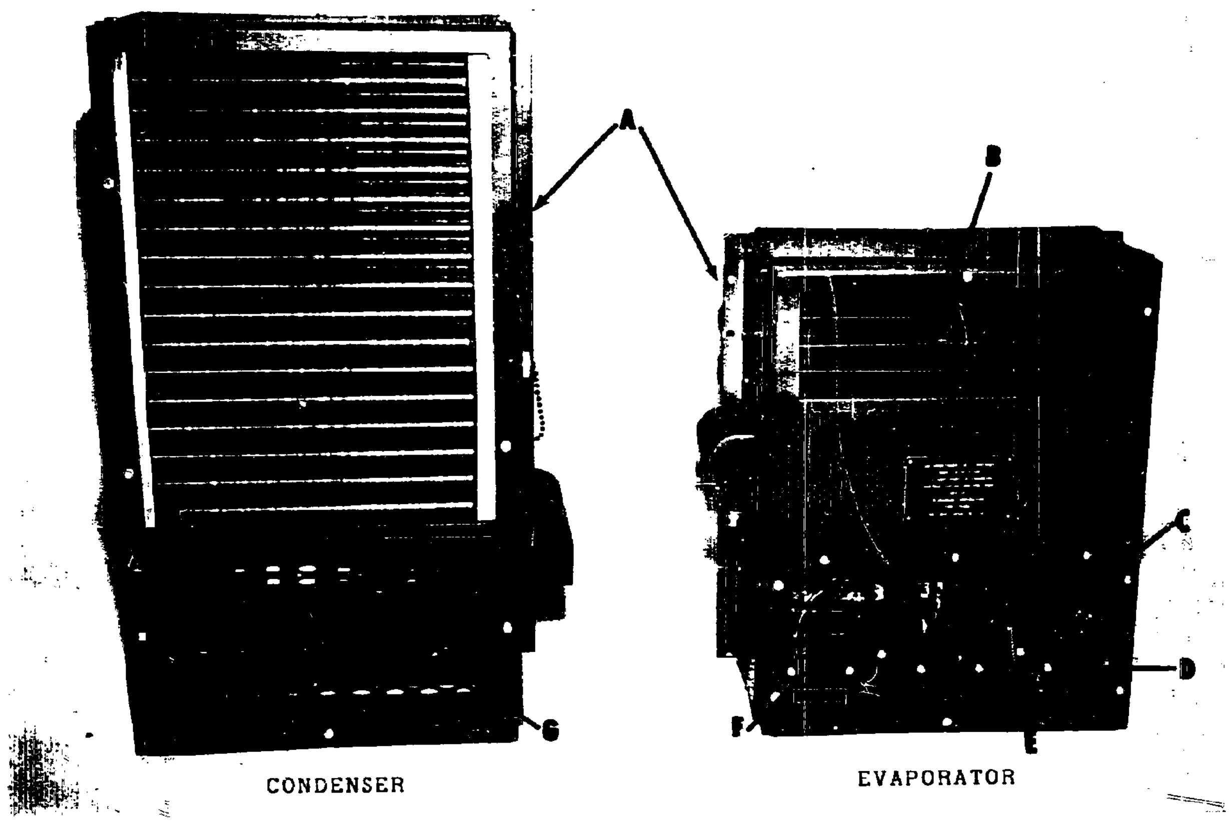


Fig. 1. (A) Mounting frame angle; (B) fresh air inlet damper; (C) adjustable air discharge grilles; (D) fresh air damper switch; (E) thermostat control switch; (F) off-heat-vent-cool switch; (G) condenser air inlet grille.

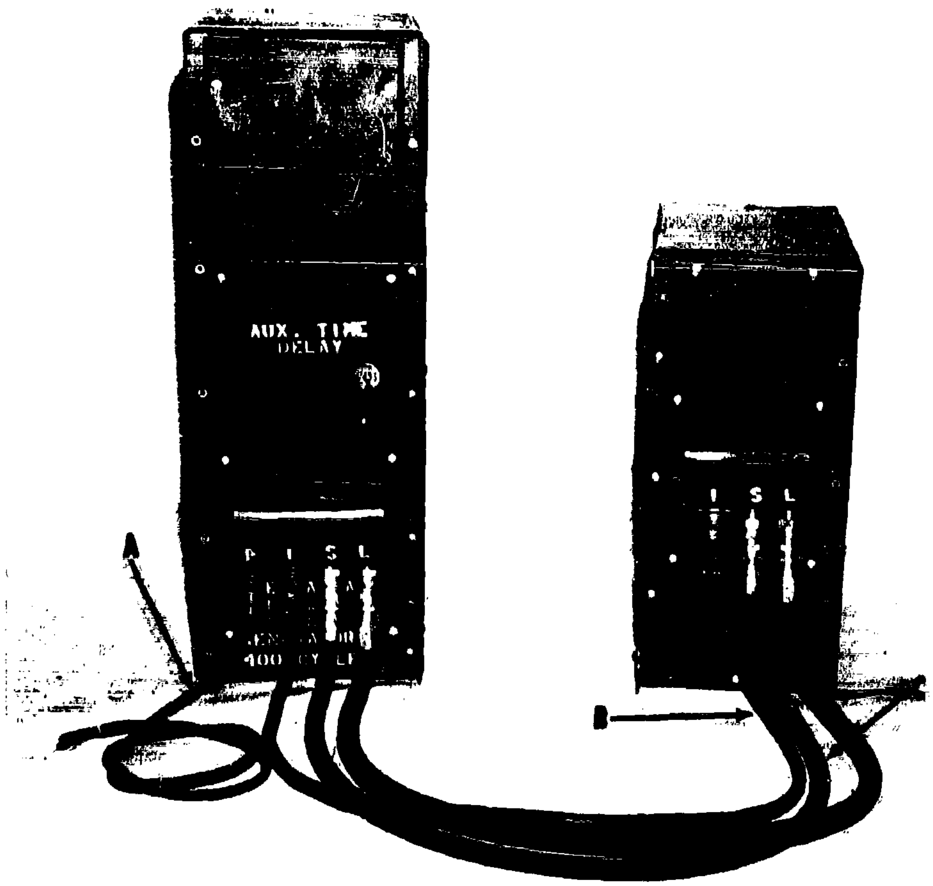


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Fig. 2. (A) Power supply cable; (B) interconnecting power cable; (C) interconnecting refrigerant hoses.

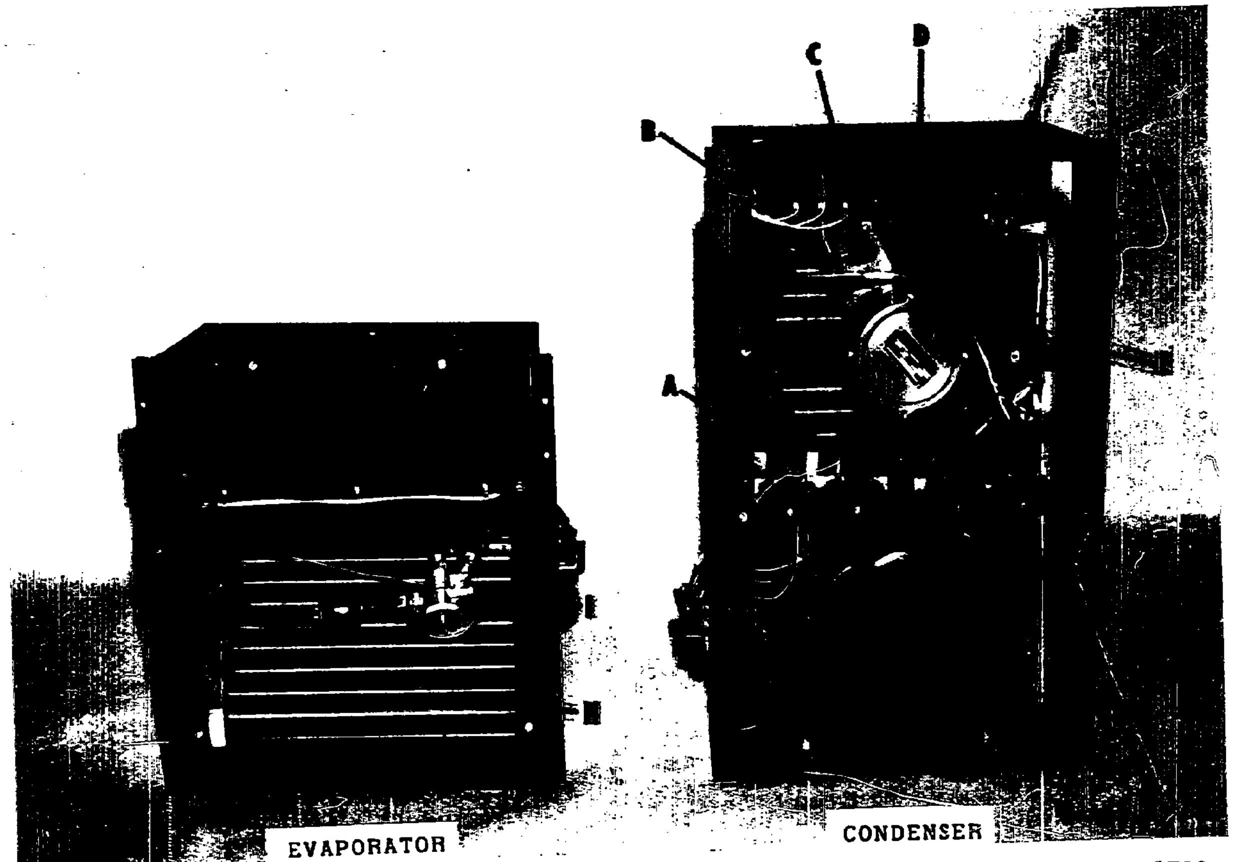


Fig. 3. (A) Electrical relay; (B) transformer; (C) condenser fan; (D) condenser fan motor; (E) electrical relay; (F) rectifier; (G) compressor; (H) evaporator coils; (I) expansion valve.

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Fig. 4. (A) Interconnecting power cable receptacle; (B) interconnecting refrigerant hose grommets; (C) evaporator coils; (D) condensing coils; (E) compressor; (F) receiver; (G) heater.

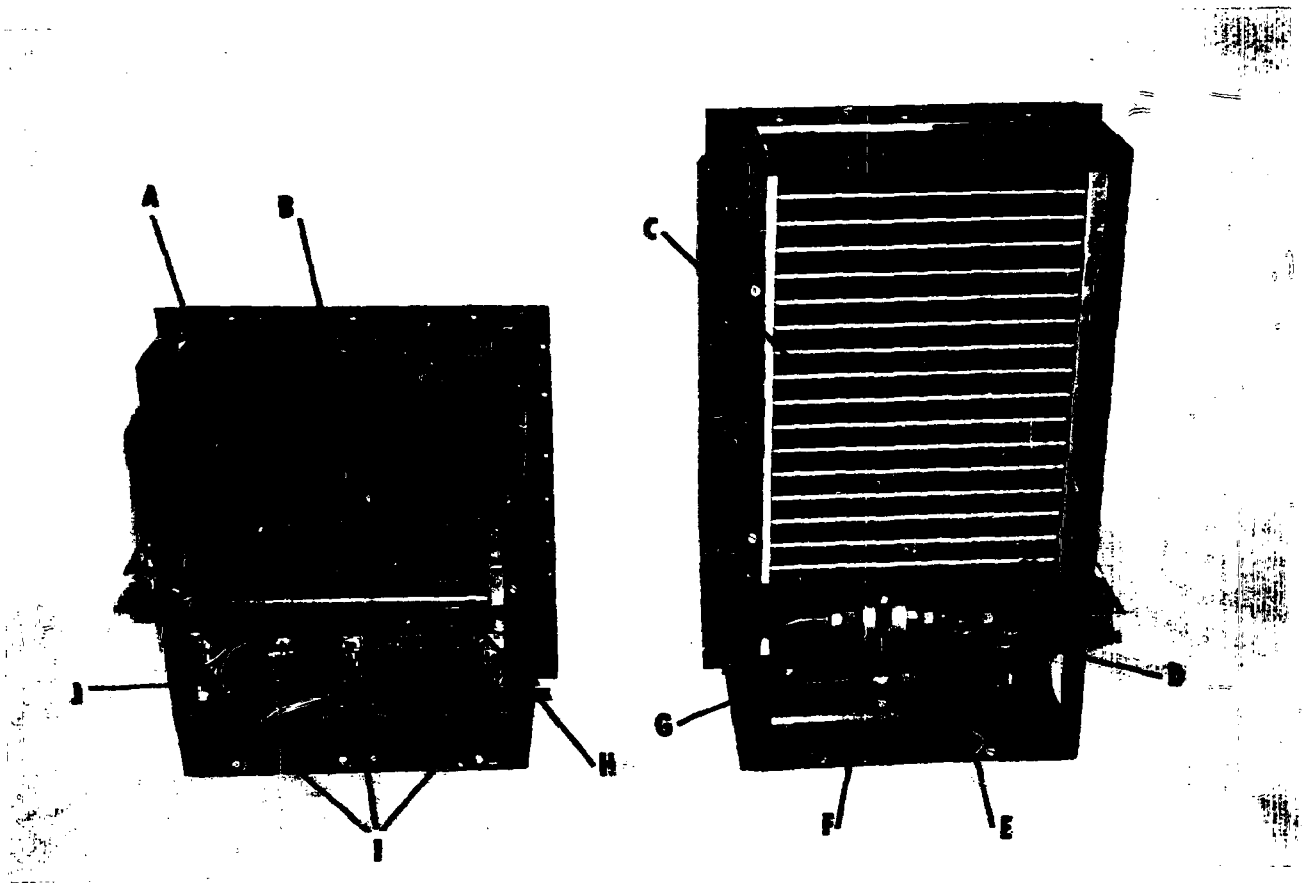



Fig. 5. (A) Fresh air damper; (B) evaporator fan motor; (C) condensing coils; (D) sight glass; (E) receiver charging valve; (F) receiver tank; (G) filter-drier; (H) evaporator coils; (I) controls; (J) heater.

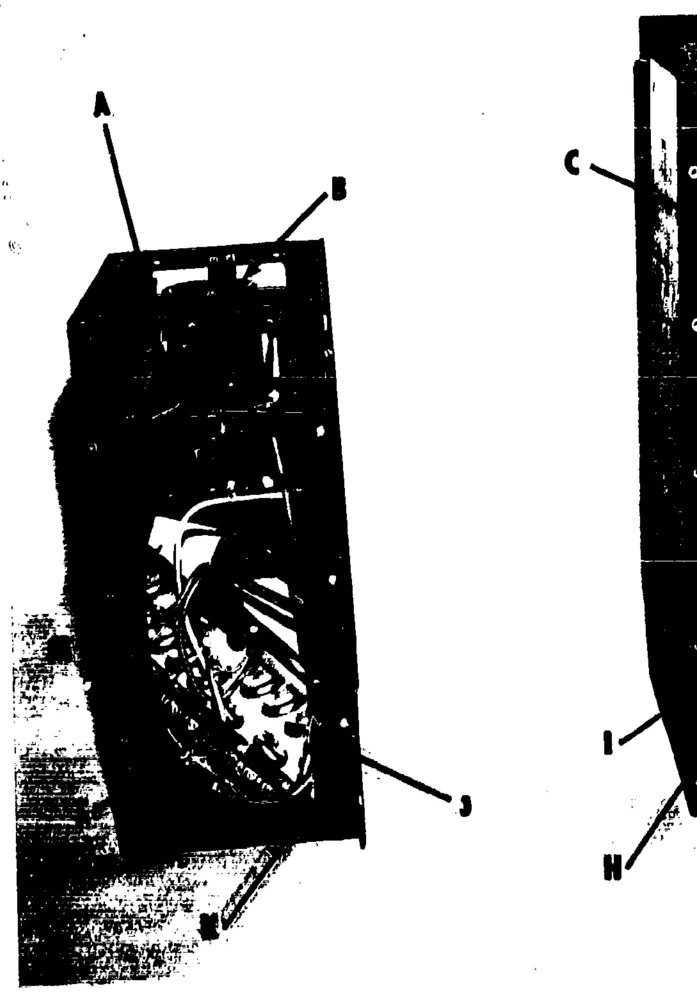



Fig. 6. (A) Evaporator fan; (B) evapora
(C) condensing coils; (D) condenser fan
time-delay relay receptacle; (F) interco
hose grommets; (G) interconnecting power
(H) electrical power supply cable recepta
(J) evaporative coils; (K) evaporator cc
outlet; (L) heater; (M) air filter.

to both sections are made through quick-disconnect self-sealing couplings.

There are two electrical versions of the 6,000-Btu/hr unit. The type 60 unit uses single-phase, 115-volt, 60-cycle power. The second unit is referred to as type 400 and uses 3-phase, 208-volt, 400-cycle power.

The evaporator section of the type 400 unit is equipped with electrical-resistance heaters of 1,250-watt capacity. Heaters are optional in the 60-cycle version.

The condenser section is $14\frac{1}{2}$ inches wide by 26 inches high by $9\frac{1}{4}$ inches deep. The evaporator section is $14\frac{1}{2}$ inches wide by 18 inches high by $8\frac{1}{4}$ inches deep. Weight of the unit is 105 pounds for the type 400 unit and 115 pounds for the type 60 unit.

a. Test of First-Stage Design.

(1) Capacity and Performance. Capacity and performance tests were performed by Electrical Testing Laboratories, Inc. (ETL), New York, New York. Testing of the type 60 unit was conducted on a Redmanson Corporation unit, serial number 702, in May 1960. Capacity test for the type 400 unit was conducted at ETL on a Redmanson unit, serial number 7018, in June 1960. This test was re-run in August 1960 due to an error in recording of data in the June test.

Capacity tests were made in accordance with American Society of Refrigerating Engineers (ASRE) Standard 16-56, "Methods of Rating and Testing Air Conditioners," modified to incorporate military test requirements. The balanced (ambient room) calorimeter method was employed for the test.

(a) Test and Test Setup. Under this test, the sensible heat and latent heat removed from the air in the "indoor" test room by the evaporator section are replaced by the indoor calorimeter air reconditioner which, at ETL, uses electric strip heaters and an evaporator tray filled with water also electrically heated. When the wet bulb and dry bulb thermometers located in the stream of sampled air taken 6 inches in front of the reconditioner outlet show stable thermal equilibrium at specific conditions, the total heat input into the indoor reconditioner during the test period of 1 hour (modified by any heat leakage through the enveloping surfaces of the test room) is the cooling capacity of the cooling unit under test.

The cooling capacity is again determined, as a check, from the "outdoor" test room into which is injected all the heat removed from the indoor test room by the unit under test. The latent heat and sensible heat introduced into the outdoor room are removed by the outdoor calorimeter air reconditioner which uses heat transfer coils through which chilled water circulates. Electric strip heaters are provided in the reconditioner to reheat the dehumidified air as needed. Stable thermal equilibrium in this project (because of the physical arrangement of the units tested) is indicated by the thermocouples located in the stream of air 1 inch in front of the condenser inlet grille of the test unit. The total heat removed by the reconditioner during the test period of 1 hour, reduced by the thermal equivalent of the electrical input to the unit under test and to the reconditioner and also modified by heat leakage through the enveloping surfaces of the test room, is the "check" cooling capacity of the unit under test. The ASRE standard specifies that the capacities determined from the two calorimeters shall agree within 6.0 percent.

The electrical inputs to the unit under test and to the two test rooms are measured by calibrated instruments (voltmeters, ammeters, and wattmeters), and energy input is measured by integrating watt-hour meters. The quantity of water evaporated in the indoor room is measured by a modified hook gauge used in conjunction with a vernier scale which indicates the water level in the evaporator tray. Condensed water is collected from the evaporator section to the test unit and measured. The quantity of chilled water circulated in the outdoor reconditioner is measured with precision water meters. Dry bulb and wet bulb air temperatures and water temperatures are measured with precision glass thermometers graduated to $0.1^{\circ}$ F.

The test rooms are each 12 feet long (parallel to the wall separating the two calorimeters), 8 feet wide, and 8 feet high. They are each surrounded by an interspace. The wall which separates the interspace as well as the test rooms is insulated with 8-inch-thick blocks of cellular material known as "Foamglass." The walls, ceilings, and floors are completely covered with aluminum-sheathed panels which are impervious to vapor. The floors, in addition to the aluminum panels, are covered with 1/8-inch-thick linoleum.

The interspaces are maintained at the temperatures of their respective test rooms (where feasible; otherwise measured) to minimize heat transfer. The temperature of the air at each of the five surfaces of each test room exposed to the interspaces is measured by resistance thermometers and is recorded by a calibrated automatic multipoint recorder at $7\frac{1}{2}$-minute intervals.

For these tests, the unit was installed with the evaporator section in the indoor test room and the condenser section in the outdoor test room. The two separate sections were connected by the flexible refrigerant and electrical lines which passed through the separating wall.

The air-discharge deflection louvers were set to blow the air away from the air intake of the unit in conjunction with a short duct. The test unit controls were set for maximum cooling with the ventilation damper closed.

Capacities of the type 60 and type 400 units are as indicated in Tables II and III and Fig. 7.

Table II. Results of Capacity Test - Type 60 Unit (First-stage Design)

| Data Obtained | Run 1 | Run 2 |
|---|---|---|
| (a) Operating Temperatures | | |
| Outside Air ($^{o}$F d.b.) | 95.0 | 125.0 |
| Inside Air ($^{o}$F d.b.) | 80.1 | 90.0 |
| Inside Air ($^{o}$F w.b.) | 67.0 | 75.2 |
| (b) Electrical Input | | |
| Test Voltage (Maintained) (volts) | 115.0 | 115.0 |
| Frequency (cps) | 60 | 60 |
| Line Current (amps) | 8.4 | 9.8 |
| Total Power Input (watts) | 955 | 1090 |
| Energy Consumed (whr.) | 955 | 1090 |
| Power Factor (percent) | 99 | 97 |
| (c) Rating* | | |
| Total Rated Capacity (Btu/hr) | 4800 | 4600 |
| Latent Capacity (Btu/hr) | 600 | 600 |
| Sensible Capacity (Btu/hr) | 4200 | 4000 |
| Water Evaporated (lb/hr) | 0.6 | 0.6 |

* Ratings are reported to the nearest 100 Btu/hr.

Table III. Results of Capacity Test - Type 400 Unit (First-stage Design)

| Data Obtained | Run 1 | Run 2 | Run 3 |
|---|---|---|---|
| (a) Operating Temperatures | | | |
| Outside Air (°F d.b.) | 95.0 | 107.0 | 125.0 |
| Inside Air (°F d.b.) | 80.1 | 87.0 | 89.7 |
| Inside Air (°F w.b.) | 67.2 | 73.0 | 75.3 |
| (b) Electrical Input | | | |
| Test Voltage (Maintained) (volts) | 206 | 207 | 207 |
| Frequency (cps) | 400 | 400 | 400 |
| Line Current (amps) | | | |
| Phase $T_1$ | 9.4 | 9.6 | 9.8 |
| Phase $T_2$ | 9.0 | 9.2 | 9.5 |
| Phase $T_3$ | 8.4 | 8.6 | 8.8 |
| Total Power Input (watts) | 1390 | 1425 | 1510 |
| Energy Consumed (whr.) | 1390 | 1425 | 1510 |
| Power Factor (percent) | 47 | 48 | 49 |
| (c) Ratings* | | | |
| Total Rated Capacity (Btu/hr) | 5800 | 6400 | 5600 |
| Latent Capacity (Btu/hr) | 500 | 900 | 600 |
| Sensible Capacity (Btu/hr) | 5300 | 5500 | 5000 |
| Wt. Water Evaporated (lb/hr) | 0.5 | 0.9 | 0.6 |

* Ratings are reported to the nearest 100 Btu/hr.

(b) Test Results. During tests of the type 60 and the type 400 units, a slight amount of condensate dripped from the evaporator section of the test unit onto the test room floor. Inspection of the type 60 evaporator section indicated that the condensate was "blowing off" the evaporator coil, accumulating in the base of the evaporator section, and leaking out along the bottom edge of the section. Inspection of the type 400 unit revealed that the resistance heater bracket was in contact with the fins of the cooling coil. This condition caused condensate to strike the heater bracket and be blown down to the bottom of the section. The heater bracket was separated from the coil for the remainder of the test. A slight amount of moisture continued to leak due to blow off from the coil.

A considerable amount of air recirculation occurred at the condenser section for both the type 60 and the type 400 unit. The top half of the intake grille

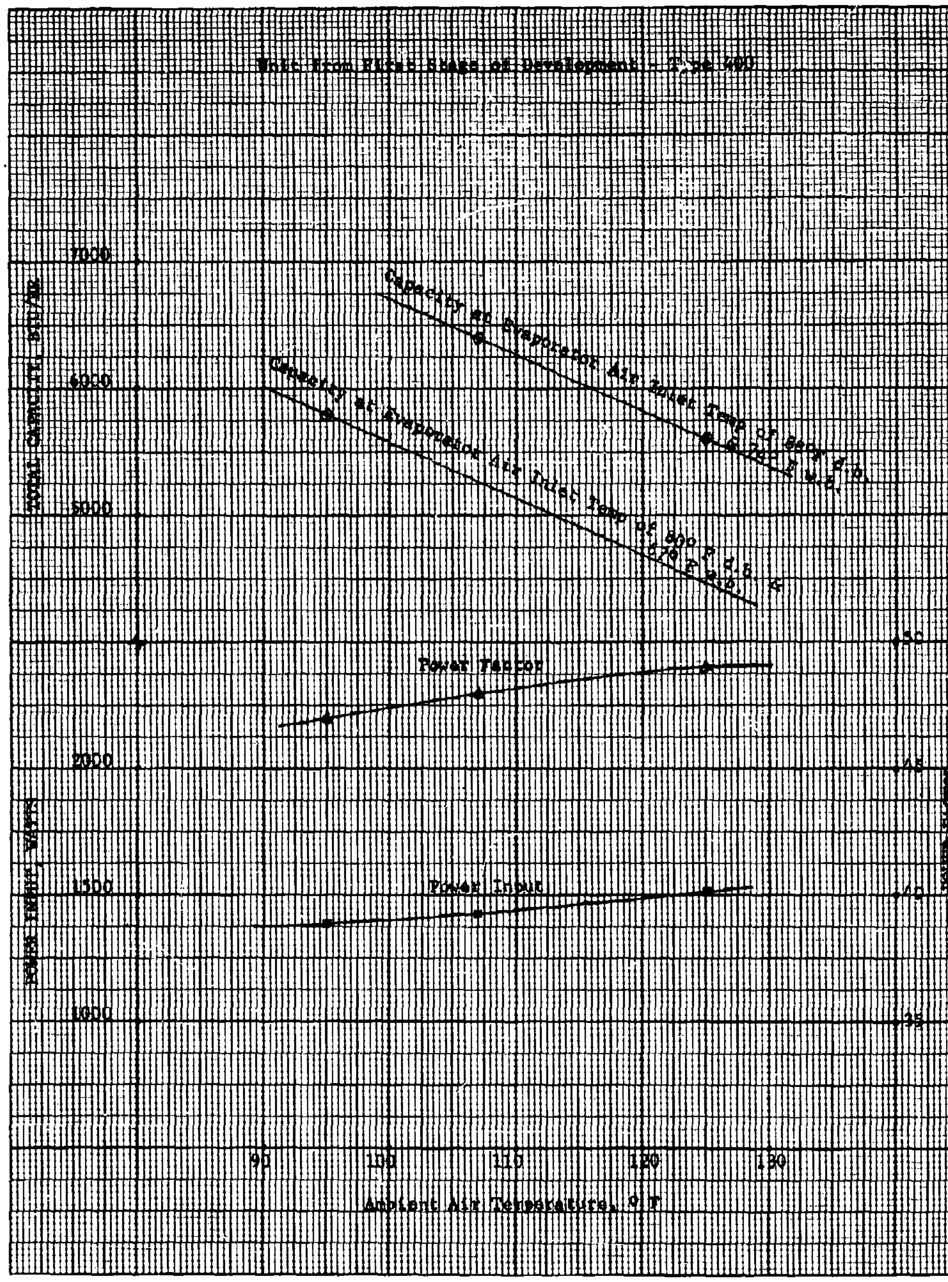



Fig. 7. Capacity test results (first-stage design).

received considerable high-temperature air rejected by the condenser above it.

The amount of recirculation for the evaporator section varied with different settings of the direction discharge louvers. With the louvers set to discharge the air horizontally (side-to-side), recirculation of air on the evaporator side was minimized; when the air was discharged downward, recirculation was eliminated. However, considerable recirculation exists where the air is discharged upward, since the cooled air is then "short circuited" into the intake air grille. Both units (type 60 and type 400) were tested with the louvers set for horizontal discharge.

During capacity tests of the type 400 unit, the overload protector caused the compressor motor to become de-energized at condenser inlet air temperatures above approximately 105° F. The protector was replaced to determine whether the original one was defective or was not suited for its application. The replacement caused de-energization of the compressor-motor at condenser inlet air temperatures of 122° F and above. The overload protectors were electrically bypassed in order to complete the capacity test.

(2) Air Flow Test.

(a) Test and Test Setup. The quantity of air discharged from the evaporator was measured with an air flow meter which was attached to the housing by a short duct of airtight material. The flow meter was an "ASHVE" type equipped with such components as a calibrated orifice and air-straightening devices. Measurements of static and velocity pressures were made with inclined-tube manometers. Wet bulb and dry bulb thermometers with 0.2° F graduations were provided to measure the quantity of the air. A variable-speed blower located beyond the velocity chamber was used to bring air at the test unit back to atmospheric pressure (free air discharge).

(b) Test Results. The type 60 test evaporator unit delivered 205 cfm standard air flow. The type 400 evaporator unit delivered 225 cfm standard air flow.

(3) Endurance Test.

(a) Type 60 Unit. A type 60 Redmanson unit, serial number 702, completed 2,369 hours of successful

endurance testing at USAERDL. During this period of testing, only minor problems such as blowing of a fuse and malfunctioning of a capacitor relay were experienced. These problems will be resolved in forthcoming modification of the type 60 units.

(b) Type 400 Unit. No formal endurance tests have been conducted on the type 400 unit; however, extensive research and development tests of identical production units in Pershing System shelters have served as an effective endurance test. As a result of these tests, the following problems were determined to exist:

1 Excessive voltage drop in control circuitry.

2 Condenser fan motor overloaded.

3 Electrical relays vibrate out of sockets.

4 Undersized compressor overload protection.

5 Refrigerant hose connection needs fixed mounting.

6 Condensate drip pan needs extending.

7 More panel fasteners needed.

The above problem areas were resolved in final development of the type 400 unit.

(4) Vibration and Shock Tests. Vibration tests were conducted in accordance with Military Specification MIL-E-4970, procedure III, except that for inputs of plus or minus 1.3 g, where 2 to 27.5 cps is specified, the test equipment was not able to register frequencies below 7 cps. At 2 cps, the test equipment was able to obtain displacements not in excess of 0.5 g. The test covered a period of one week, starting 1 February 1960, with intermediate downtime to replace failed parts.

(a) Type 60 Unit Condenser Section. The section was vibrated from 10 to 500 cps for resonance points. Resonant frequencies included 58 and 12 cps. Lesser resonant frequencies noted were 345, 230, and 110 cps. During vibration test frequencies, the following failures occurred at the listed frequencies:

1. 52 cps. Mounting bracket for "round" capacitor broke (thickness of bracket increased from 17 to 15 gauge and width increased to 1 inch); modified mounting bracket for round capacitor broke (21 gauge by 11/16-inch-wide bracket changed to 15 gauge by 1 inch wide and bend radius increased).

2. 17 to 32 cps. Frame broke at right lower rear corner at weld (gusset added, same thickness as frame); failure in frame occurred in same location as above (second gusset added to frame and angle, mounting bracket extended the entire length of the unit with two additional 3/16-inch bolts added, and angle projected rearward 1/4 inch for easier mounting without interference of projecting panel).

Upon completion of tests of the condenser section, examination of the section revealed bent fan blades and evidence of contact between fan blades and fan venturi. Fins of the condenser coil were also bent due to the displacement of fan blades during the vibration test. An additional fan motor mounting bracket was added, and the cross-section area of fan brackets was increased.

(b) Type 60 Unit Evaporator Section. The section was vibrated from 2 to 500 cps with resonant points of 130, 80, 36, 24.5, and 18 cps. Major resonant point occurred at 18 cps. The following failures occurred at 18 cps, and corrections were as indicated: Excessive displacement of fan and motor (number of mounting brackets increased); excessive displacement of thermostat capillary tube (tube secured); louver fasteners loosened (number of fasteners increased).

Examination at the end of the test also revealed a loosening of damper control wire from the control mechanism. The conduit of this control wire was secured to the frame of the section in order to eliminate resonance and breakage of wire.

(c) Type 400 Unit Condenser Section. Structurally, type 400 units are identical to the type 60 units except for mounting brackets for various electrical components. Structural frame members and mounting brackets were strengthened so that the type 60 structural failures would not reoccur.

The following failures occurred during a scan between 7 cps at 0.4 g to 150 cps at 3 g for a period of 90 seconds: Resistor broke off transformer (remounted); relay came out of socket (strap provided to retain relays); and fan blades hit venturi (bracket added and cross section increased).

A second scan covering a period of 15 minutes and frequencies from 7 to 135 cps was made. The following failures occurred: Transformer broke off (transformer removed); relay dust cover screw came loose (replaced).

(d) Type 400 Unit Evaporator Section. A scan of frequencies from 10 to 130 cps and back to 65 cps was made over a period of 15 minutes with the following failures:

1. Fan bracket broke off at approximately 65 cps (number of brackets increased).

2. Heater coil went into resonance at 100 cps; however, no failures occurred.

3. After completion of test, it was observed that the fan blade had failed. (This resulted from the bracket failure which was corrected as indicated in 1 above.)

The above strengthening of structural members of the unit and addition of brackets were incorporated in the second-stage design. Other design features were added to strengthen the evaporator section and to eliminate problem areas. These features are reported in paragraph 6.

(5) Humidity Test. The unit was installed in the balanced calorimeter-type test chamber in an upright position. A small shield was placed above the unit to prevent any drippage of condensate on the unit. The temperature of the test chamber was maintained between 71 and 100° F, and the chamber was vented to the atmosphere to prevent any pressure buildups. The velocity of the circulating air throughout the test chamber was maintained at less than 150 ft/min.

During the first 2 hours of the test, the temperature was gradually raised to 155° F and then held constant for a period of 6 hours. The temperature of the test chamber was then slowly reduced to the initial starting temperature over a period of 16 hours. This completed one cycle. Ten complete cycles were conducted over a period of 240 hours. The

relative humidity during each cycle was maintained in excess of 95 percent by utilization of distilled water.

At the end of the complete test (10 cycles), the unit was inspected for rusted or damaged structures, deterioration of the electrical system, malfunctioning of capacitors and relays, and general appearances.

No deficiencies were detected during the inspection.

(6) Compressor Motor Trip-out Test. This test was conducted in a balanced calorimeter-type chamber at USAERDL on 25 March 1961, using a Redmanson Model unit containing a Tecumseh compressor, Serial number 225787, driven by an electric motor. The evaporator air inlet temperature was held constant at 90° F dry bulb, and the condenser air inlet temperature was allowed to vary from 100° F dry bulb until the overload protector tripped out. This test was also performed on a Redmanson Model unit containing a Tecumseh compressor, Serial number 712506, driven by a different electric motor.

No deficiencies were noted when the unit containing the first electric motor was used. However, the results when the second motor was used were very erratic and unreliable. At times, the overload tripped out at 115° F condensing temperature but at other times did not trip even for condensing temperatures as high as 175° F.

(7) Motor Winding Temperature Test. This test was conducted at USAERDL on 23 March 1961 using a Redmanson Model unit containing a Tecumseh compressor, Serial number 225787, driven by an electric motor. The unit was placed in a balanced calorimeter-type test chamber. The evaporator side of the unit was maintained at a constant dry bulb temperature of 90° F and a constant wet bulb temperature of 75° F. The temperature of the condenser unit was raised in increments of 5° F from 135 to 155° F dry bulb; data was recorded at each increment after thermal equilibrium was obtained. The motor winding temperature was determined by the Seeley resistance method. The equation used to calculate the motor winding temperature was

$T_h = \frac{(R_h)}{R_c} (390.1 + T_c) - 390.1$; where $T_h$ = motor winding temperature, hot; $R_h$ = motor winding resistance, hot; $R_c$ = winding resistance, cold; and $T_c$ = winding temperature cold. Thermocouples, voltmeters, ammeters, and wattmeters were used to obtain necessary data. The results of this test are shown in Table IV and Fig. 8.

Table IV. Results of Motor Winding Temperature Tests (First-stage Design)

| Data Obtained | Results | | | | |
|---|---|---|---|---|---|
| Condenser Inlet Temperature (°F d.b.) | 135 | 140 | 145 | 150 | 155 |
| Evaporator Inlet Temperature (°F d.b.) | 90 | 90 | 90 | 90 | 90 |
| Resistance of Winding & Leads, cold (ohms) | 1.400 | 1.400 | 1.400 | 1.400 | 1.400 |
| Resistance of Leads, shorted (chms) | 0.234 | 0.234 | 0.234 | 0.234 | 0.234 |
| Resistance of Leads, cold (ohms) | 1.166 | 1.166 | 1.166 | 1.166 | 1.166 |
| Temperature of Windings, cold (°F) | 70 | 70 | 70 | 70 | 70 |
| Resistance of Leads, hot (ohms) | 1.598 | 1.627 | 1.633 | 1.660 | 1.670 |
| Temperature of Windings, hot (°F, calculated) | 241.1 | 251.2 | 260.9 | 265.0 | 270.0 |

The temperatures of the motor windings were found to be below the critical winding temperature of 302° F at condenser inlet air temperature of 155° F. Since maximum design condenser air inlet temperature is only 125° F, the motor winding temperature during normal operation is well below its critical point.

(8) Time-Delay Relay Voltage Drop Test. This test was conducted by installing two complete type 400 units to the same power source and connecting a time-delay relay into the circuit. The circuit was energized with 400-cycle power, and the units were turned on. One unit was activated immediately, and the time-delay relay activated the second unit after a delay of 30 seconds in order to prevent the sudden demand on the power supply that would be in evidence if both units were activated simultaneously.

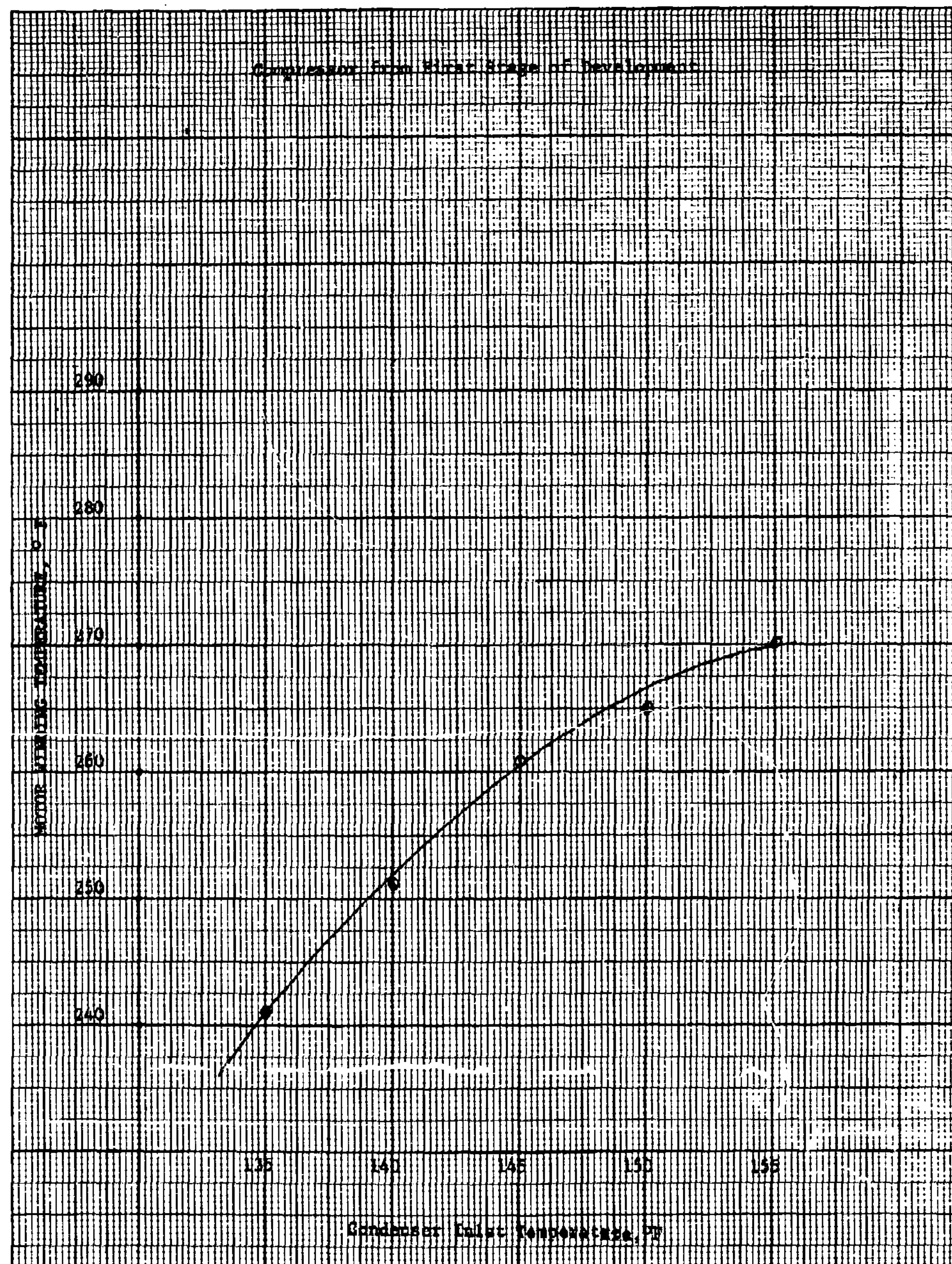



Fig. 8. Winding temperature test results (first-stage design).

It was found that the voltage drop through the relay and the interconnecting cables was so great that there was insufficient voltage remaining to activate the second unit. This deficiency has been corrected in the redesigned units.

b. Analysis of First-Stage Design Test Results.

(1) Capacity and Performance Test.

(a) Type 60 Unit. The capacity was found to be below the required capacity of 6,000 Btu/hr, being 4,800 Btu/hr at 95° F dry bulb ambient and 4,600 Btu/hr at 125° F dry bulb ambient. This represents a deficiency of 20 percent for the former and 23.3 percent for the latter. This is 16 percent and 19.3 percent, respectively, in excess of the maximum acceptable deficiency of 4 percent as stated in the design specifications. On the basis of these results, the unit was not acceptable. This deficiency can be easily corrected by proper expansion valve adjustment. The unit is currently being modified and procured under a limited quantity procurement by Chicago Procurement Office.

The supply voltage, frequency, power input, condensing pressure, and suction pressure are within specified limitations. The power factor of the unit was exceptionally good, being 99 percent at an ambient of 95° F dry bulb and 97 percent at an ambient of 125° F dry bulb.

The performance factor or the ratio of the total capacity to the total power input was found to be 5.03 Btu/watt/hr at the ambient temperature of 95° F dry bulb and 4.22 Btu/watt/hr at the ambient temperature of 125° F dry bulb. The design specifications require that this ratio be greater than 5.0 Btu/watt/hr at all operating temperatures between 80 and 125° F dry bulb. The deficiency in the performance factor at the 125° F dry bulb ambient is expected to be corrected in the second-stage design.

The sensible heat factor (SHF) or the ratio of the sensible capacity to the total capacity was found to be 87.5 percent at the operating temperature of 95° F dry bulb and 87.0 percent at the operating temperature of 125° F. The specifications state that the SHF should be within the range of 60 to 80 percent at all operating ambients between 80 and 125° F. The actual SHF exceeds those specified; however, they are considered desirable since air conditioning load requirements are toward a

higher sensible load percentage. The purchase description was revised to reflect this change in SHF requirements.

(b) Type 400 Unit. The capacity of this unit was found to be 5,800 Btu/hr at a condensing air temperature of 95° F dry bulb, 6,400 Btu/hr at a condensing air temperature of 107° F dry bulb, and 5,600 Btu/hr at a condensing air temperature of 125° F dry bulb. This represents deficiencies of 3.3 and 6.5 percent at 45 and 125° F, respectively. The maximum allowable deficiency is 4.0 percent. The capacity is satisfactory with exception of the rated value at the 125° F ambient. This deficiency has been corrected in the second-stage design.

The voltage, phase, frequency, condensing pressure, and suction pressure are within the specified limitations.

The SHF was found to be 91.4 percent at an ambient of 95° F dry bulb, 86 percent at an ambient of 107° F dry bulb, and 89.3 percent at an ambient of 125° F dry bulb. As stated above, higher values are desirable and shall be retained in the unit design.

The performance factor of this unit should be greater than 4.45 Btu/watt/hr for all operating temperatures between 80 and 125° F dry bulb, if the specifications are to be met. The performance factor of the test unit was found to be 4.17 Btu/watt/hr, 4.49 Btu/watt/hr, and 3.71 Btu/watt/hr at operating temperatures of 95, 107, and 125° F dry bulb, respectively. The deficiencies in the unit when performing at 95 and 125° F dry bulb should have been corrected in the second-stage design; however, this is not the case. Extensive redesign would be needed to improve this performance factor. No work in this direction is contemplated.

The total power input in all tests is greater than the maximum specified power input of 1,350 watts, being 1,300 watts at 95° F dry bulb, 1,425 watts at 107° F dry bulb, and 1,510 watts at 125° F dry bulb. This high power input results in power factors of 47, 48, and 49 percent at ambient temperatures of 95, 107, and 125° F, respectively. The design specifications designate that power factors should be in excess of 75 percent. An attempt to remedy these deficiencies has been incorporated in the second-stage design, but further development would be necessary to accomplish the desired results. It is now felt that a 75 percent power factor for 400-cycle motors at 3,600 rpm is not within the state of the art.

(2) Air Flow Tests. The results of the air flow test for both the type 60 unit and the type 400 unit are satisfactory, and the units meet design requirements.

(3) Endurance Tests. Extensive endurance tests have been completed on both the 60-cycle unit and the 400-cycle unit. The test on the type 60 unit was a formal test, and the test on the type 400 unit was a service-type test. Only minor discrepancies were noted, and these have been eliminated in second-stage design.

(4) Vibration Tests.

(a) Type 60 Unit Condenser Section. All the failures that occurred were structural failures and occurred at frequencies of either 52 cps or 17 to 13 cps. These failures are expected to be eliminated in the second-stage design.

(b) Type 60 Unit Evaporator Section. All failures of this section were structural failures and occurred at resonant frequencies of 18 cps. All discrepancies are expected to be eliminated in the second-stage design.

(c) Type 400 Unit. Failures observed in this test were not so extensive or so recurrent as in the type 60 test because the results of the type 60 test were applied to the type 400 unit before it was tested. This was possible since the frame structures of the two units are identical. The minor discrepancies that occurred have been corrected in the second-stage design.

(5) Humidity Test. Results of the humidity test for both the type 60 unit and the type 400 unit indicate that the unit has met the requirements.

(6) Compressor Motor Trip-out Test. Results of the test of the unit containing the compressor with the first electric motor were satisfactory. The results of the test of the unit containing the compressor with a different motor were unsatisfactory, were very erratic and inconsistent, and did not meet requirements. It was found that the trip-out temperature could be reduced 10 to $15^{\circ}$ F by enclosing the overload protector so that circulating air could not pass the protector.

(7) Motor Winding Temperature Test. Results of the motor winding temperature test indicated that the motor winding temperature was well below the critical winding temperature

of 302$^{\circ}$ F. At the maximum operating condenser air inlet dry bulb temperature, the motor windings reached a temperature of only 270$^{\circ}$ F. Operating at normal conditions, the winding temperature would be less than 240$^{\circ}$ F.

(8) Time-Delay Relay Voltage Drop Test. Results of this test were unsatisfactory. The voltage drop through the relay unit and the interconnecting electrical cables was so great that there was insufficient voltage reaching the second unit to activate the unit. This discrepancy has been corrected in the second-stage design by use of a transformer and a selenium rectifier.

6. Second-Stage Design. The redesigned unit is compatible with the general description of the original units. The accessories used in the second-stage design are the same as those used in the first-stage design.

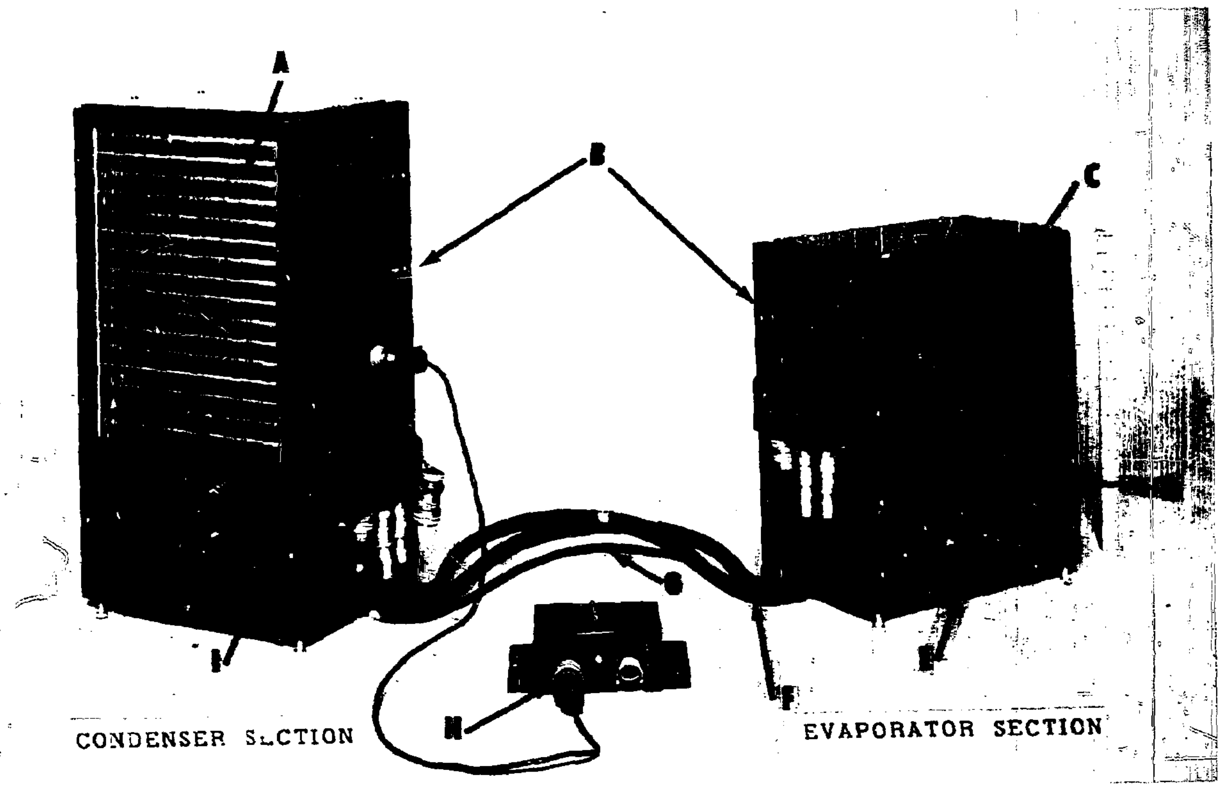
The first-stage type 400 unit was manufactured by the Therm-Air Manufacturing Company. (The contract for the second-stage type 60 unit is still in the development phase. The proposed modifications are described in paragraph 7. Other information will be incorporated in a future supplement to this report.) Figures 9 through 13 show the second-stage type 400 unit.

a. Tests of Second-Stage Design, Type 400.

(1) Capacity and Performance Tests. The capacity test of a preproduction Therm-Air Manufacturing Company unit, serial number 4021, was conducted at ETL on 5 October 1960. Performance test was conducted on the above preproduction unit at Therm-Air Manufacturing Company on 28 and 29 December 1960. This performance test was used as a basis for acceptance of production air conditioners. Results of these tests are shown in Tables V and VI and Fig. 14.

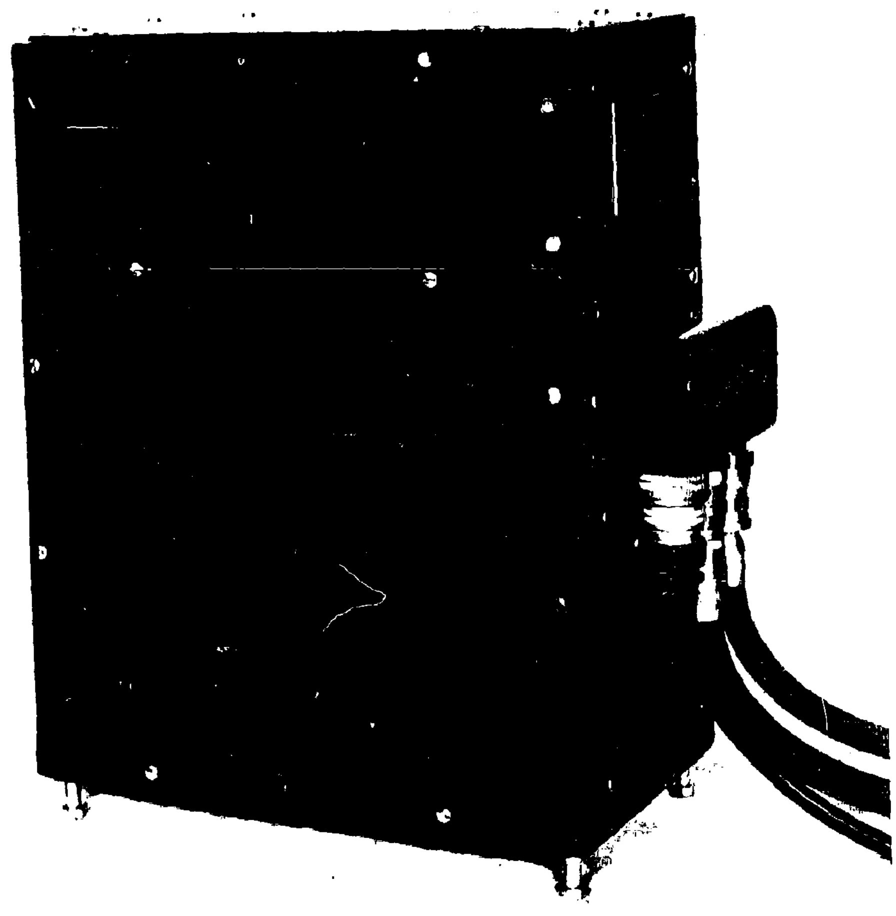
The capacity and performance tests were conducted in accordance with ASRE Standard 16-56 and in accordance with Military Specification MIL-E-4970A (USAF), dated 1 June 1955. The method of test is described in paragraph 5a(1) of this report.

(2) Sensible Capacity Test. A unit sensible capacity test was conducted at USAERDL during 9 to 16 May 1961 on preproduction unit, Therm-Air Manufacturing Company, Serial number 4017. Results of this test are as indicated in Table VII.



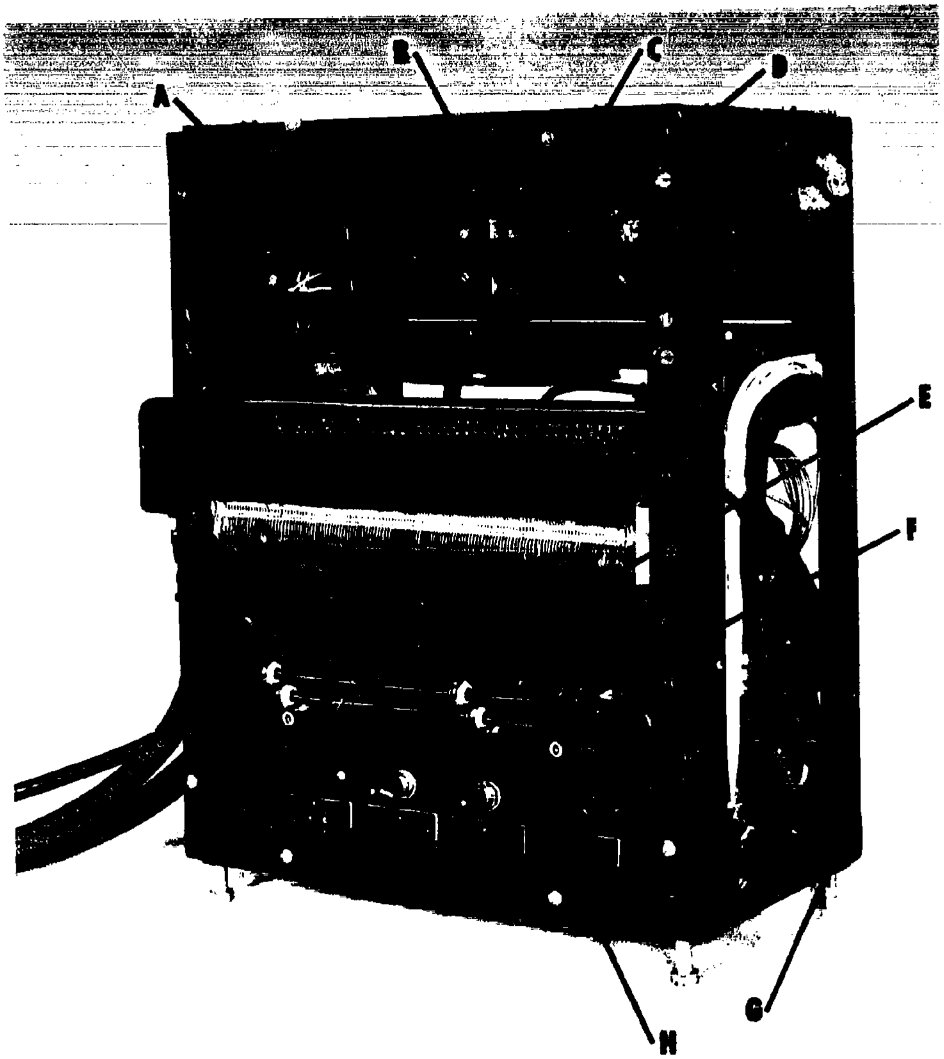

H3809

Fig. 9. (A) Condensing coils; (B) mounting frame angle; (C) fresh air damper; (D) adjustable discharge grilles; (E) control panel; (F) interconnecting power cable; (G) interconnecting refrigerant hose; (H) auxiliary time-delay relay; (I) condenser air inlet grille.



H3817

Fig. 10. Rear of evaporator section.




H3815

Fig. 11. Evaporator section, front view: (A) Electrical relay; (B) evaporator fan motor; (C) evaporator fan location; (D) fresh air damper; (E) evaporator coils; (F) heater; (G) evaporator condensate drip pan outlet; (H) control panel.

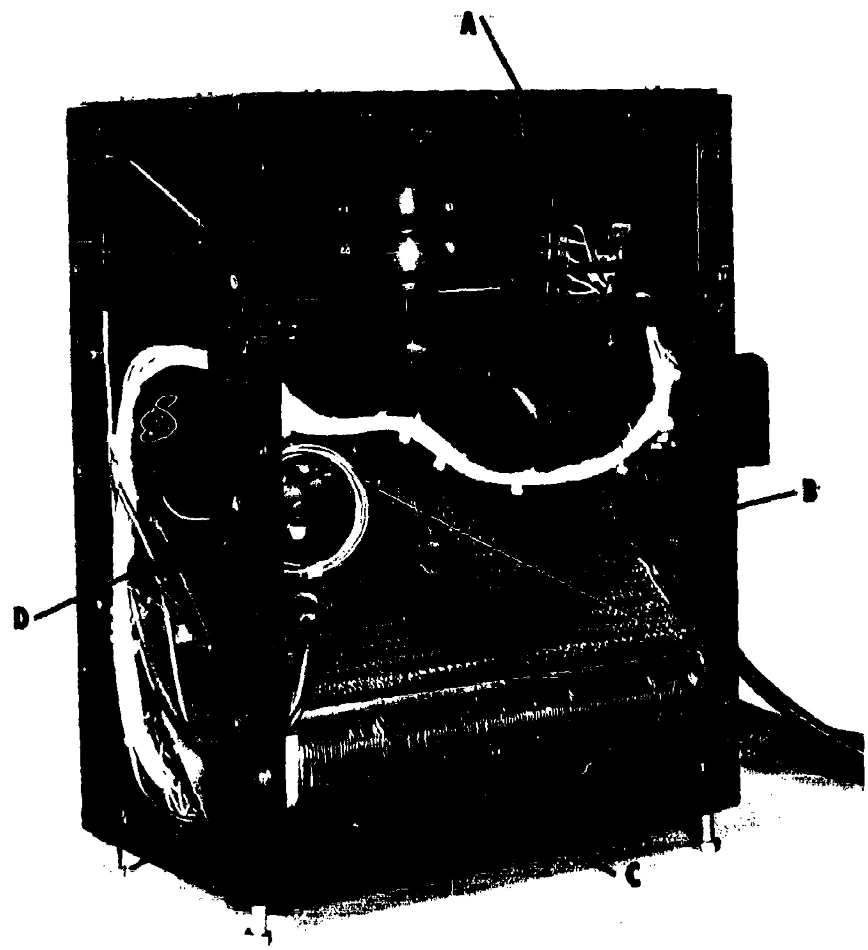
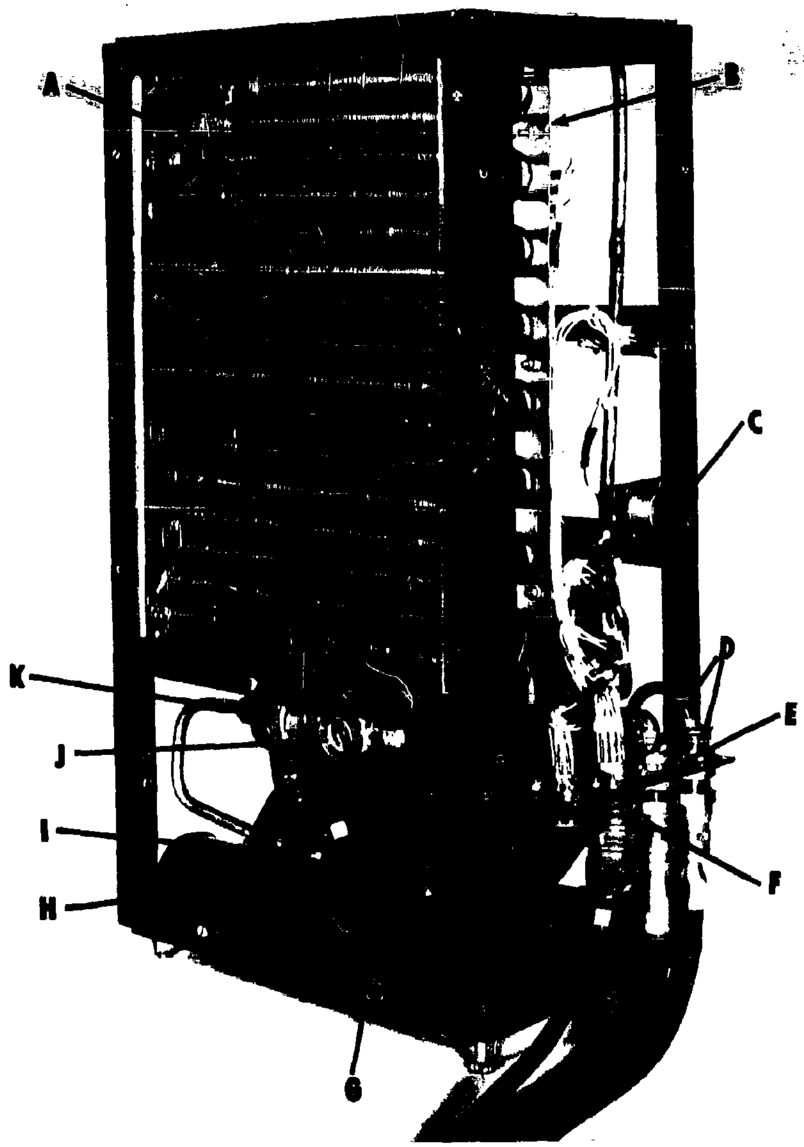



Fig. 12. Evaporator section, rear view: (A) Electrical relay; (B) air filter; (C) evaporator drip pan; (D) expansion valve.




H3811

Fig. 13. Condenser section, front view; (A) Condensing coils; (B) condenser fan and motor location; (C) auxiliary time-delay electrical receptacle; (D) interconnecting refrigerant hose grommets; (E) electrical power supply cable receptacle; (F) interconnecting power cable receptacle; (G) compressor; (H) receiver; (I) receiver charging valve; (J) sight glass; (K) filter-drier.

Table V. Results of 400 Cycle Capacity Test
(Second-Stage Design)

| Data Obtained | Run 1 | Run 2 |
|---|---|---|
| (a) Operating Temperatures | | |
| Outside Air (°F d.b.) | 95.5 | 125.0 |
| Inside Air (°F d.b.) | 80.0 | 90.1 |
| Inside Air (°F w.b.) | 67.0 | 75.05 |
| (b) Electrical Input | | |
| Test Voltage (maintained) (volts) | 208.0 | 208.0 |
| Frequency (cps) | 400 | 400 |
| Line Current (amps) | | |
| Phase $T_1$ | 10.4 | 11.4 |
| Phase $T_2$ | 10.1 | 11.4 |
| Phase $T_3$ | 9.9 | 10.1 |
| E - Total Power Input (watts) | 1670 | 1720 |
| Energy Consumed (whr) | 1670 | 1720 |
| Power Factor (percent) | 46 | 47 |
| (c) Ratings* | | |
| Total Rated Capacity (Btu/hr) | 6350 | 5925 |
| Latent Capacity (Btu/hr) | 1480 | 1590 |
| Sensible Capacity (Btu/hr) | 4870 | 4335 |
| Wt Water Evaporated (lb/hr) | 1.4 | 1.5 |

* Ratings are reported to the nearest 100 Btu/hr.

Table VI. Performance Test Results
(Second-Stage Design)

| Data Obtained | Result |
|---|---|
| (a) Operating Temperatures | |
| Evaporator Inlet ($^{o}F$ d.b.) | |
| Data Point 1 | 94.6 |
| Data Point 2 | 94.5 |
| Data Point 3 | 94.7 |
| Data Point 4 | 94.4 |
| Average | 94.55 |
| Evaporator Outlet ($^{o}F$ d.b.) | |
| Data Point 1 | 68.2 |
| Data Point 2 | 66.6 |
| Average | 67.4 |
| Evaporator Inlet ($^{o}F$ w.b.) | |
| Data Point 1 | 74.9 |
| Data Point 2 | 74.1 |
| Average | 74.5 |
| Evaporator Outlet ($^{o}F$ w.b.) | |
| Data Point 1 | 64.7 |
| Data Point 2 | 64.3 |
| Average | 64.5 |
| Dry Bulb ($^{o}F$) | 27.15 |
| (b) Operating Pressures (psig) | |
| Condensing | 169.5 |
| Suction | 45.5 |
| (c) Electrical Supply | |
| Total Power Input (watts) | 1,726 |
| Supply Voltage (volts) | 209.5 |
| (d) Overload Check | |
| Evaporator Fan | |
| Minutes in | 0.77 |
| Minutes out | 0.98 |
| Condenser Fan | |
| Minutes in | 0.55 |
| Minutes out | 0.42 |
| (e) Control Check | |
| Vent - Heat - Thermostat | OK |
| Off - Cool - Thermostat | OK |

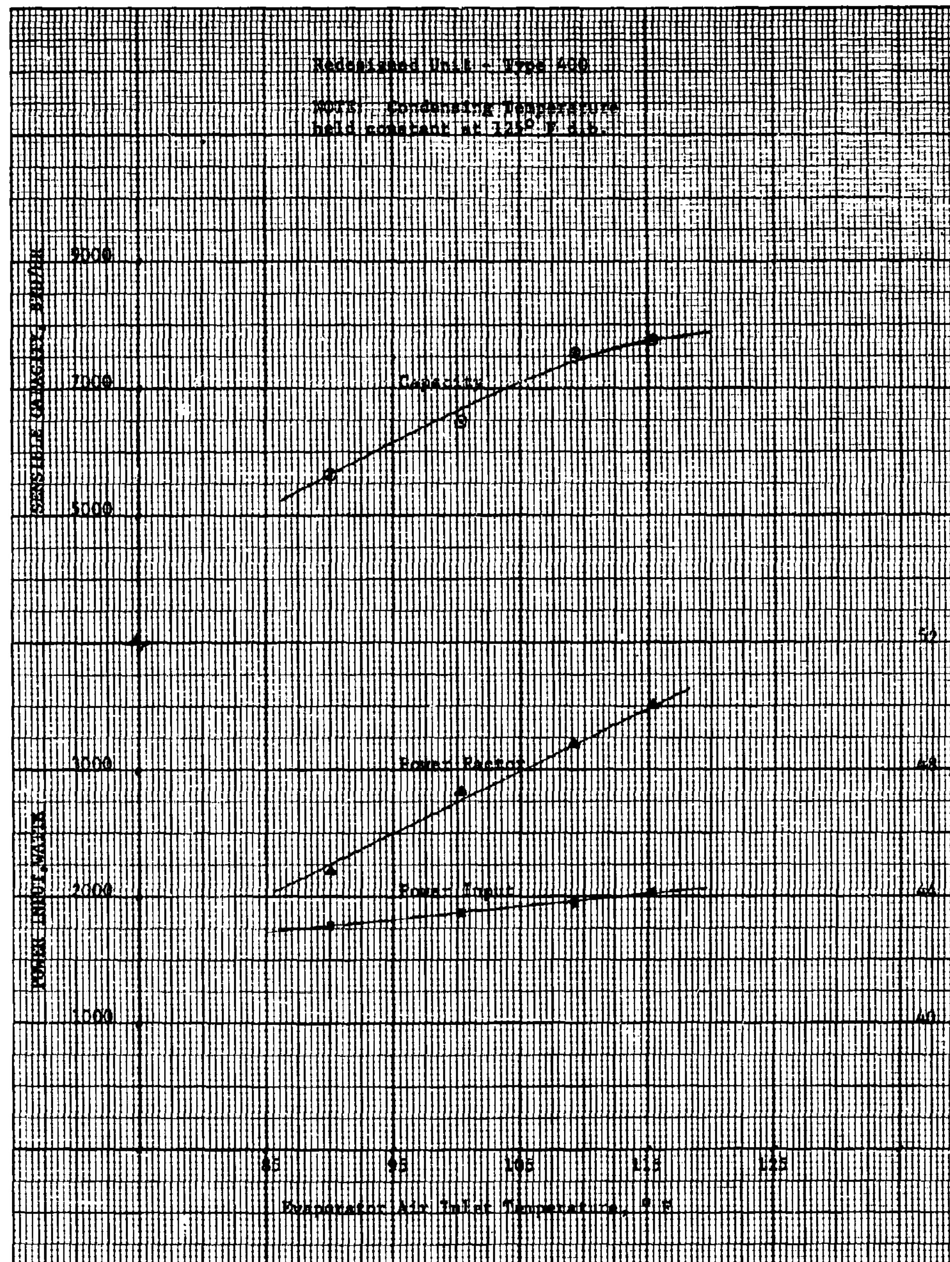


Fig. 14. Capacity test results (second-stage design).

Table VII. Results of Sensible Capacity Test for Various Evaporator Inlet Temperatures (Second-Stage Design)

| Data Obtained | Test 1 | Test 2 | Test 3 | Test 4 |
|---|---|---|---|---|
| (a) Operating Temperatures | | | | |
| Condenser Inlet ($^{o}F$ d.b.) | 125.0 | 125.0 | 125.0 | 125.0 |
| Condenser Outlet ($^{o}F$ d.b.) | 148.0 | 150.2 | 151.8 | 154.3 |
| Evaporator Inlet ($^{o}F$ d.b.) | 90.0 | 100.2 | 109.1 | 115.1 |
| Evaporator Outlet ($^{o}F$ d.b.) | 70.5 | 78.8 | 84.5 | 89.4 |
| (b) Power Input | | | | |
| Total Power Input (watts) | 1758 | 1868 | 1948 | 2040 |
| Power Factor (percent) | 44.8 | 47.3 | 48.8 | 50.0 |
| (c) Capacity | | | | |
| Sensible Capacity (Btu/hr) | 5666 | 6484 | 7581 | 7760 |

The sensible capacity test was conducted in accordance with ASRE Standard 16-56, except that there was no latent input into inside room of the calorimeter test chamber.

(3) Air Flow Test. The air flow test was conducted by Therm-Air Manufacturing Company on Therm-Air Model CE 6-A-400, serial number 4021, on 28 December 1960. This test was conducted in accordance with the standards set by the ASRE and the National Association of Fan Manufacturers. A description of the method of test is given in paragraph 5a(2) of this report. The results of this test are shown in Table VIII.

Table VIII. Results of Air Flow Test (Second-Stage Design)

| Data Obtained | Result |
|---|---|
| Air Flow Velocity Pressure (in. $H_2O$, Avg) | 0.0565 |
| Barometric Pressure (in. Hg, Corrected) | 30.58 |
| Dry Bulb Temperature ($^{o}F$, Avg) | 68.2 |
| Wet Bulb Temperature ($^{o}F$, Avg) | 63.9 |
| Duct Area ($Ft^2$) | 0.25 |
| Velocity (ft/min, Calculated) | 944 |
| Flow Rate (cfm, Calculated) | 236 |

(4) Storage Test. This test was conducted by Therm-Air Manufacturing Company on 29 December 1960 on their Model CE 6-A-400, serial number 4021. The test was conducted in accordance with Military Specification MIL-E-4970A (USAF). The unit was installed in a balanced calorimeter-type test chamber in an upright position with a full charge of refrigerant stored in the receiver and the condenser in a pumped-down state. The unit was not energized. The temperature of the test chamber was raised to 150° F dry bulb and held at this temperature for 24 consecutive hours. The pressure on the condensing side of the compressor was recorded to determine if the maximum allowable system pressure was exceeded or if any leaks occurred in the system. The results of this test are shown in Table IX.

Table IX. Results of Storage Test
(Second-Stage Design)

| Time | Dry Bulb Temperature (°F) | Discharge Pressure (psig) | Suction Pressure (psig) |
|---|---|---|---|
| 1930 | 151 | 212 | 35 |
| 2030 | 151 | 234 | 71.5 |
| 2130 | 150.5 | 236.5 | 73 |
| 2230 | 152.8 | 240.5 | 74 |
| 2330 | 152.3 | 243.5 | 76.5 |
| 0030 | 152.4 | 242 | 86 |
| 0130 | 152.2 | 245 | 103 |
| 0230 | 152.5 | 245.9 | 112 |
| 0330 | 152 | 241.5 | 118 |
| 0430 | 150.8 | 240 | 124 |
| 0530 | 152 | 242 | 130.5 |
| 0630 | 151.5 | 241.5 | 137 |
| 0730 | 152 | 241 | 144.5 |
| 0830 | 150.3 | 237.5 | 149 |
| 0930 | 150 | 235 | 158.2 |
| 1030 | 150.5 | 235 | 158.5 |
| 1130 | 150 | 242.5 | NA |
| 1230 | 151.9 | 245 | NA |
| 1330 | 150.9 | 242 | NA |
| 1430 | 152 | 241 | NA |
| 1530 | 151.5 | 228.5 | NA |
| 1630 | 152 | 195 | NA |
| 1730 | 151.2 | 150 | 149 |
| 1830 | 151 | 153 | 152 |
| 1930 | 150.9 | 155 | 154 |

(5) Service Tests. The service test conducted involved application of a limited production run of the 400-cycle unit in the communications huts of the Pershing and Sergeant Missile Systems. U. S. Army Signal Research and Development Laboratory, Fort Monmouth, New Jersey, is presently conducting a service test on the application of the 60-cycle unit to their communications huts.

b. Analysis of Second-Stage Design Test Results.

(1) Capacity and Performance Test. Results of the capacity test indicated that the unit performs well at the 95° F outside temperature with a total capacity of 6,350 Btu/hr. At 125° F outside temperature, the unit produced a total capacity of 5,925 Btu/hr. This capacity is 1.5 percent below requirements of the specifications. During the latter portion of the 125° F test, an increase in evaporator fan motor current was noted. It was concluded that improper evaporator fan motor operation was responsible for the low capacity of 5,925 Btu/hr. This conclusion was borne out by results of tests at USAERDL which gave total capacities well in excess of 6,000 Btu/hr. The supply voltage, frequency, condensing pressure, and suction pressure were within specified limitations.

(2) Sensible Capacity Test. Results of the sensible capacity test show a marked increase in sensible capacity of the unit with increased evaporator inlet temperatures. The power input of 1,720 watts was very high and exceeded the design specifications of 1,350 watts by 28 percent. As a result of this high power input, the power factor was only 46 percent. The requirements indicate that the power factor should exceed 60 percent. The increase in the size (horsepower) of the condenser fan was partially the cause of the increased power input. Further development of a compressor motor is expected to decrease the power requirement and increase the power factor rating.

The SHF and the performance factor are 74 percent and 3.4 plus Btu/watt/hr, respectively. The SHF is within specified values. The performance factor is in line with other Corps of Engineers units.

(3) Air Flow Test. Results of the air flow test indicate that the second-stage design complies with the design requirements, the requirements being a minimum of 200 cfm for the evaporator fan.

(4) Storage Test. The second-stage design has successfully met all requirements that pertain to storage.

(5) Service Tests. All deficiencies found in the service tests have been corrected in the design.

c. Summary of Modifications for Second-Stage Design.

(1) Structural Modifications.

(a) Addition of gussets to the frame.

(b) Increase in size of frame angles.

(c) Increase in number of fan motor mounting brackets.

(d) Relocation of frame angle holes for more secure mounting of panels.

(e) Redesign of control panels to change from three interrupted recessed control panels to one continuous recessed control panel.

(f) Increase in number of panel locking fasteners.

(g) Increase in free face area of the condenser air intake grille.

(h) Extension of evaporator drip pan to cover entire bottom of evaporator section.

(i) Welding of a metal retainer plate between refrigerant hose grommets to prevent twisting of copper tubing when attaching or removing flexible refrigerant hoses.

(2) Electrical and Control System Modifications.

(a) Replacement of four electrical relays with one electrical relay.

(b) Replacement of troublesome low-voltage control system with a high-voltage control system.

(c) Replacement of non-standard switches with standard military switches.

(d) Increase in horsepower rating of the condenser fan to insure operation within the safe operating range.

(e) Addition of selector switch to the auxiliary time-delay unit.

(f) Replacement of color coding wiring system with a numerical coded wiring system.

(g) Addition of a phase sequence device to protect the three-phase motors against reversing of direction of rotation.

(h) Redesign of auxiliary time-delay unit electrical outlet to facilitate easier connection and parallel mounting of units.

(3) <u>Refrigerant System Modifications</u>.

(a) Relocation of the receiver charging valve to permit easier charging of the unit.

(b) Installation of a moisture-detecting sight glass.

(c) Slotting of expansion valve ball seat to provide pressure equalization of the system within 3 minutes after downtime.

(d) Inclusion of optional solid tube interconnecting refrigerant lines for installation under limited space conditions.

(4) <u>General Modifications</u>.

(a) Attachment of plastic-enclosed wiring diagram to interior of rear panel of condenser section.

(b) Designation on panels with yellow paint of the location of the auxiliary time-delay electrical outlet; the total weight of the unit; and the power, frequency, phase, and voltage.

(c) Designation of the flexible refrigerant suction line hose connection grommet with an aluminum-colored "S" painted on the side panel of each section above the appropriate connection.

(d) Designation of the flexible refrigerant liquid line base connection grommet with a yellow "L" painted on the side panel of each section above the appropriate connection.

(e) Designation of the correct direction of rotation of the evaporator fan and the condenser fan located on the base of the respective motor.

(f) Metal stamping in three places on each end of the flexible and rigid refrigerant suction hose with an "S" and on each end of the flexible and rigid refrigerant liquid hose with an "L."

7. Proposed Redesign of Type 60 Unit. The redesigned type 60 unit is to be operated on 115 volts, 50 or 60 cycles, single-phase power, and the general description will be compatible to that of the original unit. The accessories will also be the same.

The modifications incorporated in the type 400 second-stage design will be included in the redesign of the type 60 unit with the exception of the electrical and control system modifications. Only item (c) and item (f) of paragraph 6c(2), "Electrical and Control System Modifications," will apply to the proposed redesign of the Type 60 unit.

8. Trouble Reports. During the development of this unit it was necessary to procure a limited quantity of 50 units for urgent requirements in Pershing. A great deal of first hand information was received on these units through a "Service Trouble Report" procedure established with The Martin Company and Collins Radio.

## III. CONCLUSIONS

9. Conclusions. It is concluded:

a. The 6,000-Btu/hr, standard-weight, multipackage, 60-cycle, air conditioning unit (type 60) in the present stage of development meets the requirements of the military characteristics and the purchase description except for low cooling capacity and low condenser fan motor horsepower. These can be corrected in the first procurement.

b. The 6,000-Btu/hr, standard-weight, multipackage, 400-cycle, air conditioning unit (type 400 second-stage design) is satisfactory and meets the requirements of the military characteristics as outlined in the project card and the purchase description, except for minor deficiencies.

c. The tested air conditioner design can only be reproduced by using manufacturing drawings as a purchase requirement.

d. Since the 400-cycle version has had the equivalent of a Service Test, it is now ready for type classification.

e. A louver arrangement to deflect the condenser discharge air upward as done in the Pershing huts would guard against possible recirculation and reduction of performance.

APPENDIX

AUTHORITY

| | | | |
|---|---|---|---|
| RDT & E PROJECT CARD | 1. TYPE OF REPORT Supplements ☐ NEW ☐ REPLACES (No. & Date) 8F71-11-001-03, 20 May 60 ☐ FINAL | | REPORT CONTROL SYMBOL CSCRD-1 (R2) |
| 2. PROJECT TITLE (TASK) AIR CONDITIONING, VAN TYPE | | 3. SECURITY OF PROJECT Unclas | 4. PROJECT NO. 8F71-11-001 |
| | | 5. 8F71-11-001-03 | 6. REPORT DATE 31 March 1961 |
| 7. BASIC FIELD OR SUBJECT Structures | 8. SUB FIELD OR SUBJECT SUB GROUP Heating & Air Conditioning, for Prefab Structures | | 9. CATEGORY SO |
| 10a. COGNIZANT AGENCY Corps of Engineers<br>b. DIRECTING AGENCY Mil Engr Div, R&D, OCE<br>c. REQUESTING AGENCY Office Chief of Engineers | 11a. CONTRACTOR AND/OR GOVERNMENT LABORATORY USA Engr Res & Dev Labs Fort Belvoir, Virginia<br>Trane Company - - - - - - - -<br>Carrier Corporation - - - - - | b. CONTRACT NUMBER<br>-DA-44-009 ENG-4604<br>-DA-44-009 ENG-4476 | |
| 12. PARTICIPATION BY OTHER MILITARY DEPTS. AND OTHER GOVT. AGENCIES | 14. SUPPORTING PROJECTS | 15. EST. COMPLETION DATES<br>DEV. N/A<br>ENGR TEST N/A<br>SERV TEST N/A<br>OPERATIONAL N/A | |
| 13. COORDINATION ACTIONS W/OTHER MILITARY DEPTS. & OTHER GOVT. AGENCIES<br>ORD Corps<br>Sig Corps<br>Army Security Agency | 16. DATE APPROVED 17 June 1960<br>18. PRIORITY IB \| 17. BUDGET CODE 5600 | 19. EST. SUPPORT LEVEL<br>[ ] UNDER $50,000<br>[ ] $50,000 - $100,000<br>[ ] $100,000 - $250,000<br>[X] $250,000 - $500,000<br>[ ] $500,000 - $1,000,000<br>[ ] OVER $1,000,000 | |
| 20. No CDOG Reference | 21. SPECIAL CODES | | |

22. REQUIREMENT AND/OR JUSTIFICATION

There is a requirement for a family of air conditioners suitable for use with specialized van and hut enclosed equipment for radar, fire control, communication, map reproduction and other similar purposes, which, in conjunction with heaters, must be capable of providing adequate operating conditions under all environmental conditions.

23. BRIEF OF PROJECT AND OBJECTIVE

a. Brief:

(1) Objective: To develop air conditioning equipment for the Army, and for the other Departments as may be required and authorized.

(2) Technical Characteristics: See Exhibit "A".

b. Approach:

(1) Engineering research and development work will be performed by the technical staff of the Corps of Engineers with such assistance of the engineering staffs of industrial firms as may be found desirable.

(2) A continuing survey will be made of new types of van type enclosures; communications radar and fire control shelters; and missile shelters to determine air conditioning requirements and to orient users toward the military air conditioners developed or under development, and in any case, to minimize the number of new items to be developed.

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|---|---|---|

(3) Feasibility and design studies will be undertaken to determine the general design and configuration of the air conditioners most suitable for satisfying the overall military requirements. Detail designs will then be prepared of the particular capacity air conditioners required, and a pilot engineering model, followed by engineer test models will be fabricated.

(4) Upon delivery of test items engineering tests will be conducted, with modifications being made as required to meet the technical characteristics. The modified items shall pass the complete engineering test procedures. Drawings and purchase descriptions shall also be modified to reflect the items passing the tests.

(5) Service test models shall be procured and furnished to the weapons systems or application for which the equipment was developed.

(6) After all tests and necessary revisions of the equipment have been accomplished, complete drawings and specifications will be prepared and forwarded to the Chief of Engineers together with recommendations regarding classification of equipment action on the developed items.

c. Subtasks: None.

d. Other information:
(1) Scientific Research: None
(2) References:
(a) DA R&D Directive Nr. 705-2, dated 2 Sep 1960, entitled HEATERS AND

Task 8F71-11-001-03

EXHIBIT "A"

TECHNICAL CHARACTERISTICS
FOR
AIR CONDITIONERS, VAN TYPE

1. The air conditioners shall be designed to provide the environment within the van, hut, shelter or enclosure that is necessary to insure proper operation of the installed electronic or other sensitive equipment, and shall:

a. Range in capacity from 6,000 to 180,000 BTU/Hr.

b. Maintain temperature, humidity, and fresh air circulation necessary for proper functioning of the primary equipment installed in the enclosure.

c. Be equipped with dust filtering devices.

d. Be compatible with chemical, biological, and radiological (CBR) filtering devices.

e. Be capable of being mounted on or in the associated van by organizational maintenance personnel without requiring extensive modifications of the van or interfering with the efficient operation of the primary equipment.

f. Be sufficiently rugged to withstand prolonged cross-country hauling in a mounted position and be capable of operation continuously for 6 months without a major overhaul.

g. Operate at a noise level such that it will not interfere with the efficient operation of the equipment in the van or shelter. Appropriate components will be treated for the elimination of interference with radio communications in accordance with applicable Signal Corps specifications.

h. Be air transportable as a part of the item of equipment in which it is to be used, and in the same phase of airborne operations.

i. Be capable of operation, as specified, at one or more of the following voltages and frequencies: 120, 208, 416 VAC and 60 or 400 cycle.

j. Be capable, where required, of being driven by either a gasoline engine or an electric motor.

k. Have mechanical and electrical parts adequately protected to prevent injury to personnel.

l. Be as light in weight and small in bulk as is compatible with other requirements.

m. Be constructed of readily available non-critical materials as far as practicable.

n. Be capable of being manufactured in quantity by modern fabrication methods.

o. Be designed with maximum simplicity commensurate with their intended performance. Ease of operation and maintenance to be considered in each feature of design.

p. Where applicable, the design of the unit shall be such that its operation will not interfere with local radar scanning devices.

q. Be treated to resist fungus and moisture, as specified.

r. Where required, be capable of interior and exterior mounting and be designed for a maximum number of applications.

s. Have the inherent capability of acceptable performance under Basic Operating Conditions and Extreme Hot Weather Operating Conditions as established in paragraphs 7a and 7c of AR 705-15, except that operation will not be required at ambient temperatures of +60°F and lower; and shall be capable of safe storage and transportation under the conditions as established in paragraph 7d of AR 705-15. Where electric heaters are specified and are an integral component, be capable of providing the rated heating output of the unit at a minimum temperature of -65°F.

t. Where necessary, be treated for the elimination of interference with radio communications in accordance with applicable Signal Corps specifications.

Category 4 - Electrical Equipment

DISTRIBUTION FOR USAERDL REPORT 1709-TR

TITLE Engineering Report of 6,000-Btu/hr Air Conditioning Unit

DATE OF REPORT 15 Mar 62 PROJECT 8F71-11-001-03 CLASSIFICATION U

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